

RESEARCH AT THE EASTERN REGIONAL RESEARCH
LABORATORY RELATED TO THE CHIP INDUSTRY

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The physical structure of the Eastern Regional Research Laboratory was first occupied as a new building in Wyndmoor, Pennsylvania, in 1940. From the beginning, the Eastern Regional Research Laboratory has conducted research on potatoes as one of its commodities. From 1940 to 1951, the program was devoted principally to non-food, industrial uses of cull and surplus potatoes. This research included: study of improved methods of producing potato starch and development of new and extended uses for this starch; preservation of potatoes by sprout inhibitors and other treatments to permit storage over long periods; hydrolysis of potatoes by action of acids and enzymes to give conversion products useful as substrates for fermentations and as adhesives; fermentations of potato hydrolyzates to give products such as alcohols and lactic acid; dehydration of potatoes to produce animal feed and flour for food and industrial use; investigation of the cell structure of potato tissue and its relation to texture; color preservation of raw, peeled potatoes.

In connection with the research on potato starch production, methods of reducing the pollutional effect of the waste products were investigated. One of the developments dealt with aerobic microbiological fermentation of the soluble wastes to lower the B.O.D. of the plant effluent. This method may find application in chip plants in situations where spray irrigation or lagooning of liquid wastes is not practicable.

From 1951 to the present, potato research at the Eastern Regional Laboratory has been largely related to food uses. This research includes the following: development of a solvent dehydration process for preparing mashed potato powder; engineering studies on dehydration of mashed potatoes on a drum drier, which led to the recently-commercialized potato flakes; development of new products such as potato nuggets and potato chip bars; basic compositional studies on potatoes comprising investigations of the nitrogen constituents, sterols, fats, and acids with the purpose of accumulating a backlog of information from which data can be drawn to attack practical problems; research on constituents responsible for chip color and a current project on preprocessing treatments to make available potatoes of desired composition for chipmaking. We shall concentrate our attention on the research relating to chip color, since that subject is of more direct interest to chip manufacturers than the other lines of research.

Chip Color Problem - Sugar Control

It would be a boon to chippers if they were able to regulate the color of their product with fair precision. Less labor would be required in inspection, less waste would be encountered in the finished product, and certainly greater sales potential would be realized for chips that are uniformly browned.

High content of reducing sugar, for example glucose, has been correlated with excessive browning more than has any other substance in potatoes. However, sugar alone is not responsible for browning during frying. This type of browning is not simply a matter of caramelization or some similar reaction. But since sugar concentration is apparently of such importance, much research has been designed to effect its control.

Removal of excessive sugar by dipping potato slices before frying results in certain disadvantages, and has not become a common practice. Hence, more attention has been given to prevention of sugar accumulation in the raw material. The following lines of research are prominent in the attempt to achieve this objective: (1) development of better sprout-inhibitor treatments to permit higher temperature storage and thus minimize sugar formation; (2) extension of knowledge concerning the enzyme systems of potato involved in the reversible reaction of sugar formation from starch; (3) investigation of the chemical reactions involved in browning during frying, in the belief that better understanding of the mechanisms will lead to control of these reactions. Several groups in the U. S. Department of Agriculture and various state agricultural experiment stations have studied sprout inhibition and this subject continues to receive attention. The Western Utilization Research and Development Division and other research organizations have conducted investigations on potato enzyme systems. The Eastern Regional Research Laboratory, Cornell University Agricultural Experiment Station, and other organizations have carried out studies on chemical constituents of potato responsible for browning.

Higher-Temperature Storage with Sprout Inhibition -

Methyl, alpha-naphthalene acetate (MENA) has been widely studied for its sprout-inhibitory properties. Several years ago staff members of the Eastern Regional Research Laboratory studied MENA in connection with its possible use in storage of early and intermediate-crop potatoes during summer months. Although the temperature used, 68° F., was higher than ordinarily employed when it is desired to avoid sugar accumulation, our results should be of interest to chippers who wish to store potatoes in periods during which the mean temperature is around 70° F. Sprouting was effectively held in check by MENA applied to the tubers in a dust. Another successful method of application was to mix the tubers with confetti impregnated with the inhibitor. The carbohydrate composition of the potatoes remained substantially unchanged during the first two or three months of storage at 68° F., with MENA. After three months, the starch content decreased while the amount of non-reducing sugars (e.g. sucrose) increased. In one experiment, the starch content of the potatoes decreased from its original value of 72% (dry basis) to 47% during the latter part of a 10-month period. Reducing sugars content remained nearly constant but non-reducing sugars increased from 6% (dry basis) to 20%. In another experiment, non-reducing sugars content went to 27% (dry basis) during 8 months' storage, at the expense of starch. Again, the reducing sugars value remained unchanged from the original.

Investigators at Boyce Thompson Institute and at the New Hampshire Agricultural Experiment Station have used carbon dioxide-enriched atmospheres for sprout inhibition during storage of potatoes at low and intermediate temperatures. While a carbon dioxide-rich atmosphere inhibits sprouting at 55° F., we found at 68° that 8-12% carbon dioxide accelerated sprouting. The exactly opposite results obtained with carbon dioxide at 55° and 68° F. is another case in the list of examples showing the specificity in the action of plant-regulating substances. Determination of the limitations of a treatment used to bring about a desired physiological effect is necessary.

Maleic hydrazide, applied as a spray to the vines a short time before the potatoes are harvested, has been used to some extent as a sprout inhibitor. Irradiation has been demonstrated by several groups to be very potent as a sprout-inhibitory treatment. However, there is apparently a small margin of safety between the level of treatment at which sprout inhibition appears and the level at which serious discoloration and decay result. Principal current interest seems to center around the possibilities of isopropyl N-(3 chlorophenyl) carbamate, which is known as CIPC. CIPC has been found by various investigators to be effective in low concentration and can be applied in vapor form to the potatoes in storage. The toxicity of CIPC is now being studied at the University of Virginia under contract with the U. S. Department of Agriculture with the supervision of the Agricultural Marketing Service, but it will probably be a few years before the required information is available. The action of other chemicals, such as the higher alcohols, is also a subject of investigation in several laboratories to appraise the value of these substances as sprout inhibitors.

Chemical Reactions in Browning

Research on the chemical reactions involved in browning has been conducted by Cornell University Agricultural Experiment Station under contract with the U. S. Department of Agriculture, with the Eastern Utilization Research and Development Division as the supervisory agent. A series of model browning system studies was made under conditions which simulate the frying of potato chips. All of the substances employed occur naturally in potato juice. It was found that 20 amino acids may react with either glucose, sucrose, or ascorbic acid to produce brown pigments. These compounds are, therefore, likely precursors to color development in chips. The effect of the amino compounds in color development varied with the concentration used and with the composition, structure, and properties of the compound. Asparagine and glutamine are quite important in chip browning due to the fact that these two amino compounds account for a large part of the soluble nitrogen in potato. Potato juice contains much phosphoric acid and potassium phosphate salts. It was found that potassium phosphates may react with sugar to produce a brown pigment and that they may also influence the reaction of other constituents in color formation.

In the study just described an evaluation was made of the relative importance of certain chemical constituents in chip browning. It was found that the concentrations of certain browning precursors, for example sugars and nitrogen compounds, change markedly during tuber development and that the protein as well as the non-protein, amino compounds may be involved. The current research along this line at Cornell Experiment Station is designed to follow chemical changes during tuber maturation and storage in the attempt to find out how to "tailor the composition" of potatoes so that they fry to the desired golden-brown color.

This paper is devoted to pertinent research at the Eastern Regional Research Laboratory related to the potato part of potato chips. Although the fat portion of potato chips causes the processor less trouble, there are also problems connected with oils and fats. This latter important work at the Eastern Laboratory will be discussed in a future paper.